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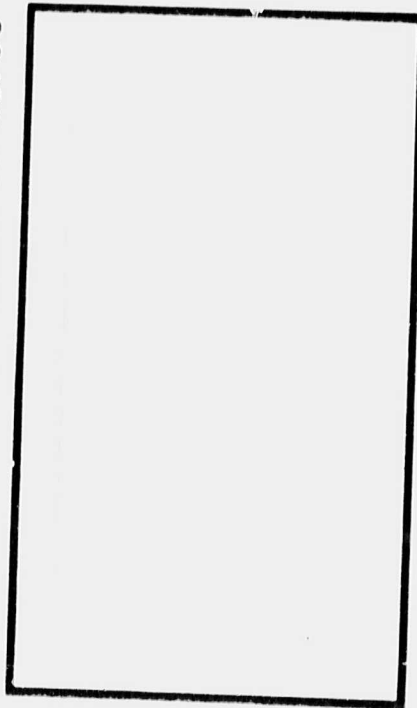
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NASA

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PREFACE

Over the years, the National Aeronautics and Space Administration developed an aggressive program to accomplish the "widest practicable and appropriate dissemination of information," as directed by the Congress. Early studies of results from this program indicated the need for linking agents, who would help NASA identify appropriate public sector problems and work with user groups to develop practicable solutions. Consequently, NASA established several applications teams at various sites around the country and directed them to seek, by all necessary and appropriate means, the transfer of NASA technologies for public benefit.

Each of the teams is chartered to concentrate its efforts in a specific field of human endeavor and is named accordingly. This report covers work performed by the Biomedical Applications Team located at the University of Wisconsin in Madison. At the end of the period covered, the Wisconsin Team will have served as a member of the NASA technology transfer program for six full years.

Biomedical Applications Teams work with all units of the medical field, from centers of research and their sponsors to the manufacturers of the

many products and services needed in modern medicine. The BATEams transfer information on NASA scientific research and technological development, help set up innovative projects to speed the adaptation of NASA technologies for medical purposes, and seek the widespread use of NASA-assisted solutions through commercial means.

Three general types of transfer projects are recognized within the NASA technology transfer program: demonstration, institutional, and commercial. In a demonstration, a device or system incorporating elements of NASA technology is developed in prototype form for others to witness, evaluate, and put to use. In the case of an institutional transfer, the beneficiary is already well known and often a co-partner in the development who makes use of the innovative technology once NASA has helped make it operational. Likewise, when a commercial transfer occurs at the conclusion of a NASA-supported project, someone has accepted the opportunity--in this case a manufacturer--to put the innovative technology to work.

The report is organized around these three types of transfer projects. To illustrate each type, a number of

projects underway during the report period were selected for presentation. Not all of these efforts have resulted in technology transfers at this writing, but dominant characteristics of the process--inter-organizational, interdisciplinary and interactive--are well represented.

To those readers who are just now learning about this applications-oriented NASA program, we invite you to consider how you might participate. If you see an opportunity for you or your organization in projects such as these, let us hear from you. To ensure that you reach the right person quickly, contact the NASA Headquarters office at the address shown at the front of this report. They will refer your inquiry to the proper NASA field center or applications team.



Dr. William N. Fetzner
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INSTITUTIONAL TRANSFERS



NASA-developed voice-controlled wheelchair is demonstrated in the House of Representatives.

Dual Axis Goniometer

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OF POOR QUALITY

The occurrence of arthritis in elderly persons is found to be an increasing problem with age, contributing to the loss of ability by these persons to care for themselves. Quantitative research on the degree of finger joint involvement and the response of arthritic joints to therapy has been limited by an inability to measure with sufficient precision finger angles at the knuckle joints in planes both parallel and perpendicular to the hand. Staff of the Veterans Administration Rheumatology Clinic at Madison, Wisconsin contend that this data is crucial to both the accurate diagnosis of the disease and to the measurement of treatment efficacy.

A search of NASA publications identified work done by the Johnson Space Center towards the development of a gauge that would simultaneously measure weld offset and peaking angles in welded assemblies. The device consists of an offset indicator coupled to a protractor, which enables it to measure simultaneously the angle between welded surfaces,

as well as any planar offset between the two surfaces. The gauge is compact and portable so as to be easily carried in a pocket for inspection purposes.

Research support was secured to develop a new dual axis angle-



measuring device incorporating the features of the NASA weld measurement gauge but modified so as to additionally measure angles with respect to two mutually perpendicular planes. The device, a type of goniometer, provides a measure of flexion contractions in the knuckles in terms of angles measured both parallel and perpendicular to the hand as well as in terms of any planar offsets between the bones of the finger and the hand.

The researchers have published in the Archives of Physical Medicine and Rehabilitation a report of the successful use of this device for the quantitative measurements of hand deformities in elderly persons resulting from rheumatoid arthritis. Because of a successful demonstration, inquiries have been received from interested manufacturers who are considering commercial production of the device in order to provide such a tool to clinicians and researchers facing the same problem elsewhere.

Pump Needed in the Development of an Artificial Pancreas

A research project is being conducted by Dr. Stewart J. Updike, Dept. of Medicine at the University of Wisconsin in Madison, to develop an artificial pancreas. This research requires the use of an ultra-low flowrate infusion pump to evaluate the glucose sensor system, which is used to control insulin administration to diabetic patients. The sensor system is an integral part of the artificial pancreas development. In order to ascertain demands of the biological system and to define the control and infusion system constraints, it is necessary to have the ability to administer minute quantities of both insulin and glucose in a very controlled manner. No commercial pumps suitable for this research are available.

A NASA literature search identified that a very low flowrate infusion pump system had been developed by Ames Research Center for the Biological Satellite Program. The pumps were used in the animal experiments on BIO-SAT program to continually flush catheters inserted within the bodies of animals and used to make arterial pressure measurements. The BATEam obtained back-up pumps on loan from the NASA contractor and supplied them to the research project. The NASA pumps perform the desired function satisfactorily and have been used during the early evaluation phase of the control system being designed as part of the artificial pancreas project.

Wearable Device for the Treatment of Petit Mal Epilepsy

Combinations of drugs are frequently employed to suppress seizures in children with petit mal epilepsy. Due to the difficulty of objectively measuring the degree and frequency of seizure activity during the child's normal activities, there is a significant problem in determining the proper dosage and evaluating the effectiveness for each one of the drugs and for their combinations. Ideally, the minimum dose of each drug should be employed so as to avoid any side effects while suppressing the seizures. Present laboratory recordings of the subject's electrical brain waves and reports by the parents do not provide enough information to optimally treat these children.

A search of the NASA computerized data base identified micropower amplifier and filtering technology. It was used in the development of a wearable device to detect from the brain waves the onset of a petit mal seizure and provide an auditory signal to avert the seizure. Preliminary clinical evaluation of the device supported by private research funds, indicated that the device was capable of identifying seizure activity in children who were undergoing drug therapy.

Evaluation of the device has been conducted by the Neurological Rehabilitation Hospital in Madison, Wisconsin, and by the Department of Pharmacology at the Arizona Health Sciences Center in Tucson. Efforts are underway to solicit commercial interest in the device so that a

quantitative tool can be made available to clinicians. This may lead to the identification of the most effective drug treatment combinations and to the optimal adjustment of dosages to minimize adverse side effects.

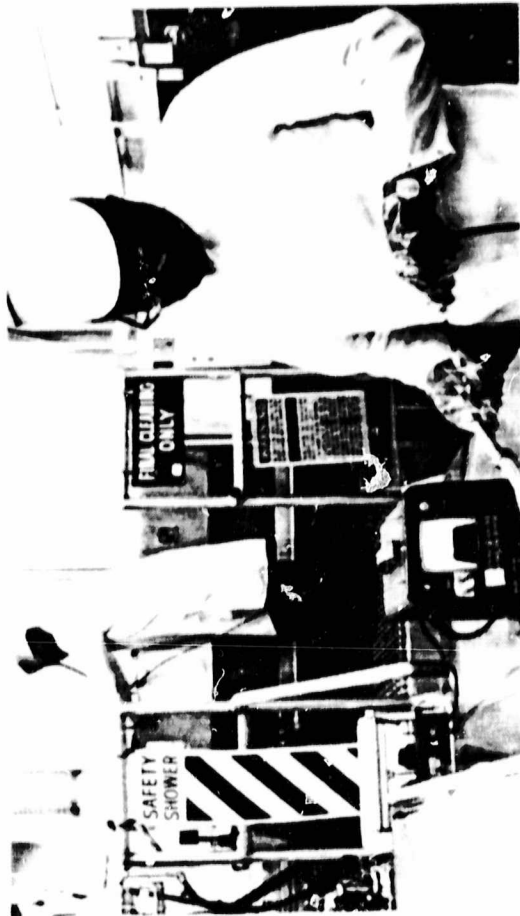


Health and Safety Hazards in the Workplace

Over the past decade, prevention of job-related illness and injury has become a topic of rising concern to the public and news media alike. Occupational diseases and injuries have an estimated \$20 billion per year impact on the nation's economy in terms of absenteeism, worker's compensation and law suits.

In response to this problem, the Occupational Safety and Health Administration has chartered universities and private institutions to provide safety and health educational services to trade union members and leadership who confront working conditions that require specialized knowledge. One such group which is active in job safety analysis is the School for Workers of the University of Wisconsin-Extension.

An inquiry received from this department prompted the BATeam to investigate what NASA documentation was available on industrial hygiene and human factors engineering. Several NASA Tech Briefs describing safety related manuals prepared for Lewis Research Center and Marshall Space Flight Center were identified, and the associated Technical Support Packages were obtained. These manuals outlined systematic field center approaches to hazard identification,



toxic substance handling, and contamination control. For example, Hazard Reduction Through Allied Experience (MSFC) and Directory of Aerospace Safety Specialized Information Sources (LeRC) were provided to the School for Workers, along with additional NASA reference materials and literature searches on safety devices, ergonomics, and anthropometric measurement.

An additional transfer of NASA expertise occurred through BATeam contact with the University of Wisconsin Safety Department, which is responsible for the formulation and enforcement of campus safety guide-

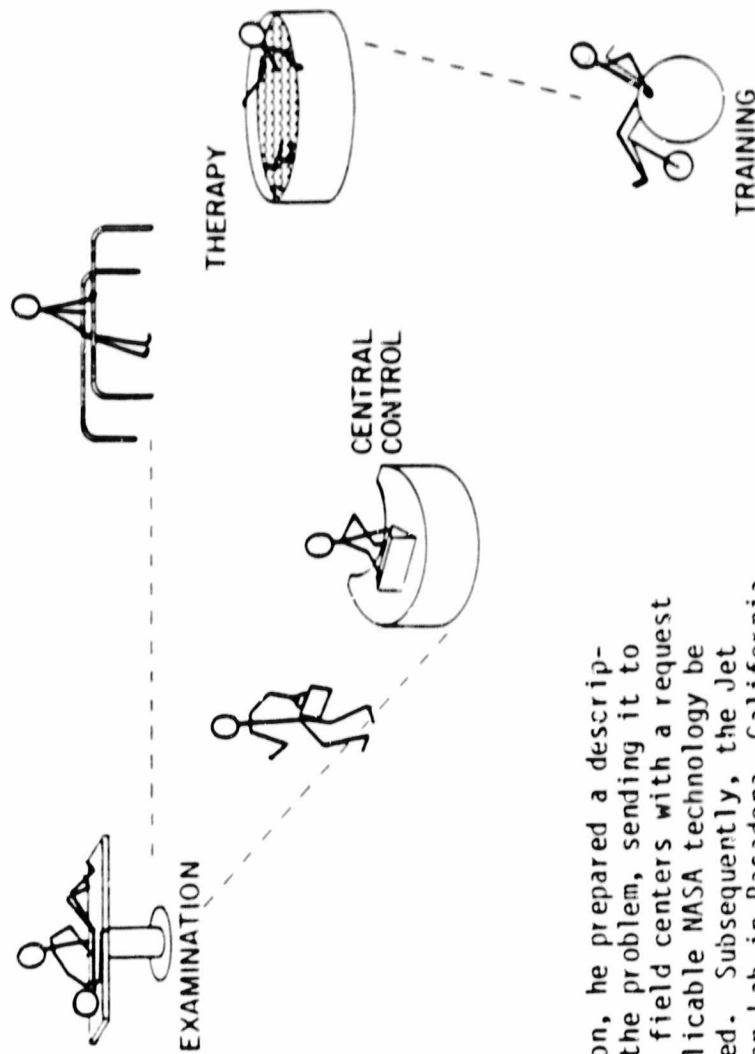
lines. The BATeam was able to provide the Safety Department with several NASA reference publications including Radiological Control Manual (MSFC), Safety in a Chemistry Laboratory (NASA-AEC), and Toxic Substances Alert Program (LeRC).

The initial exchange of information between the BATeam and the School for Workers has led to a continuing cooperative effort aimed at effectively translating the wealth of documented aerospace safety related experience into accepted and practiced hazard reduction techniques in the private sector of American industry.

Computerized Patient Scheduling

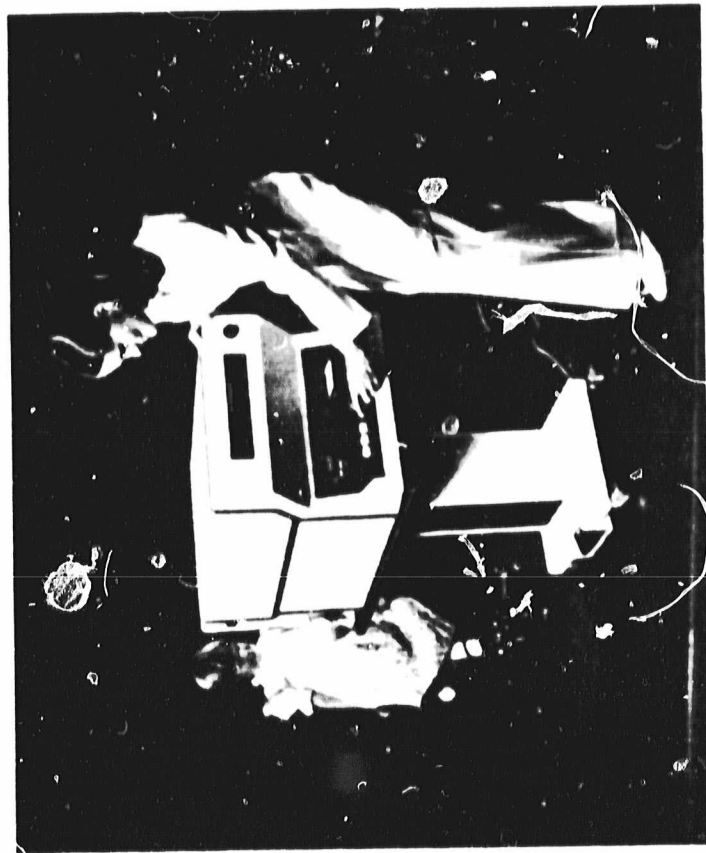
Medical treatment centers must balance patient flow with available resources such as equipment, space, materials, and the availability of various specialists from the medical staff. At the Detroit Rehabilitation Institute, records from 1978 show that on an average day, 450 patients reported for appointments and 275 new appointments or appointment changes were made. Approximately 70 physicians and therapists met with the patients. In addition to scheduling, limits imposed by equipment such as diathermy machines and elevators, a number of human factors had to be considered. Patients once assigned to specific providers usually remained in the same person's care. Multiple appointments on a single day necessitated allowances for variations in the length of sessions, distances between treatment facilities, infirmities, and rest periods between appointments.

While in Detroit, one of the UW-BATeam members stopped at the Rehabilitation Institute and discussed the problem. Upon his return



to Madison, he prepared a description of the problem, sending it to all NASA field centers with a request that applicable NASA technology be identified. Subsequently, the Jet Propulsion Lab in Pasadena, California forwarded a response from a member of its staff skilled in preparing analyses of user requirements for space-flight projects. The BATeam contacted DRI and arranged for direct discussions between the two organizations.

COMMERCIAL TRANSFERS

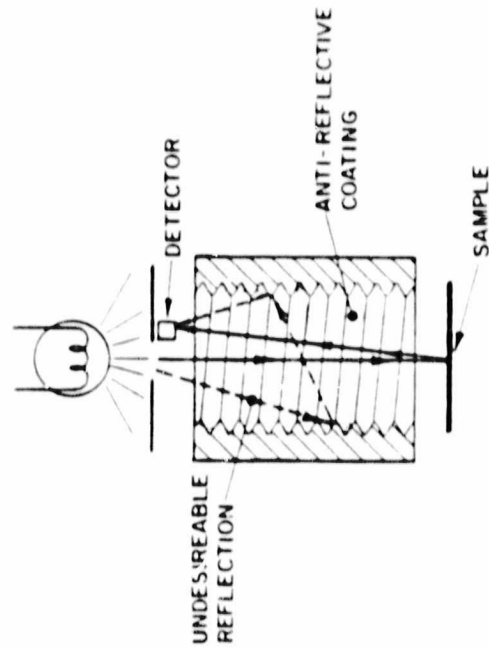


The Auto-Refractor, produced by Acuity Systems, Inc. makes use of NASA computer and optics technologies.

Absorptive Coatings for Optical Instruments

Advances in microelectronics have made possible the development of a wide variety of small, portable, and inexpensive instruments intended to accurately control the medication levels of people with chronic diseases such as diabetes and heart disease. Many of these instruments employ optical techniques to measure parametric changes in body fluids, tissues, or biochemical constituents. In one such device, the optical reflectometer, light is reflected from the substance to be measured to a sensor. Since spurious reflections arising from surfaces along the optical pathway of the light-tight enclosure can contribute to inaccuracies and inconsistent readings, it is desirable to reduce internal reflections by some means. Absorptive coatings have been developed for this purpose. However, coatings suitable for the small intricate parts found in these new optical instruments must be easily applied, durable in handling, and cheap enough to keep the overall cost down.

An absorptive coating intended for aluminum solar panels was developed at the Marshall Space Flight Center as a consequence of mission research. NASA scientists found that the coating quickly, effectively, and economically blackens the interior of optical channels and eliminates errors due to stray internal reflections.



In response to an inquiry from Ames Instruments of Elkhart, Indiana, the coating process was identified by means of a search of the NASA data base. A complete documentation package is available from the Center. The BATEam informed the company which subsequently evaluated the coating it produced by this process, finding it to be highly effective in producing an easily applied, inexpensive coating for the intricate optical paths of portable instruments. This process has contributed to the development of a new portable medical diagnostic instrument to be produced by Ames Instruments. The device will soon be made available to patients to perform specific medical analyses in their own homes and permit these patients to exercise immediate, accurate, and continuous control of their life-saving medications.

Collapsible Compressed Air Tank for Use in Field Dentistry

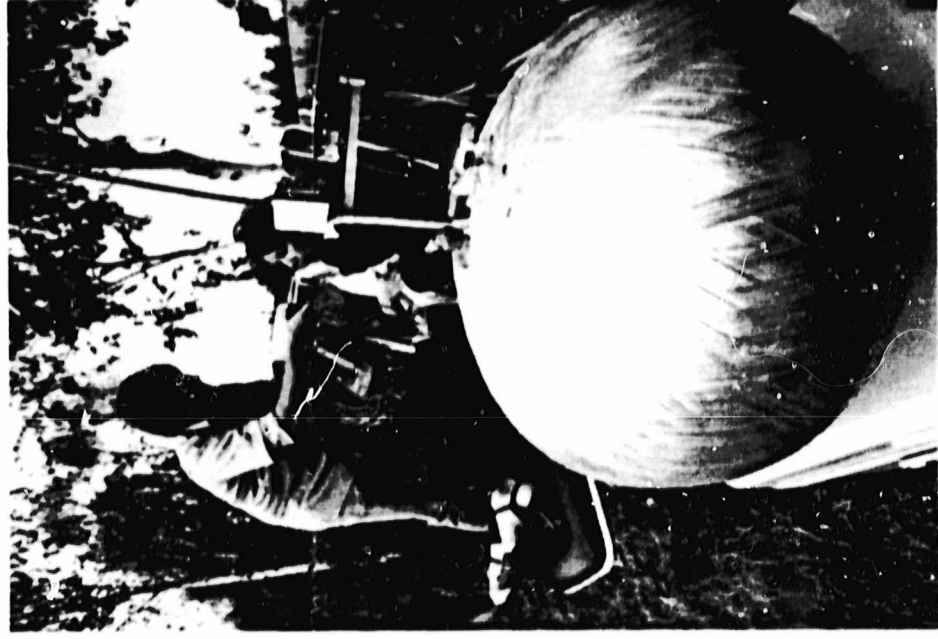
Most modern dental tools are powered by compressed air. Commercially available holding tanks are too heavy and bulky for use in remote field dentistry. A need was perceived for a lightweight, portable compressed air tank which could still withstand the rigors of field dentistry.

The BA Team sought the solution for this problem in the NASA data base; several NASA composites technology reports were found to be pertinent. By bringing together the problem originator, Dr. Robert Mallien, and an ex-NASA contractor in consultation with NASA field centers, an applications engineering effort was initiated.

The collapsible tank that emerged from the cooperative effort holds up to 38 liters of air yet weighs less than five pounds. The tank design employs principles originally developed under NASA contract to meet a need for collapsible stow-away spacecraft tanks. The outer skin is made of aramid fibers, once used by NASA as reinforcing materials in filament-wound pressure vessels, such as rocket propellant tanks. The fibers are woven in flexible resin and wound around an inflated bladder which serves as the inner tube. The

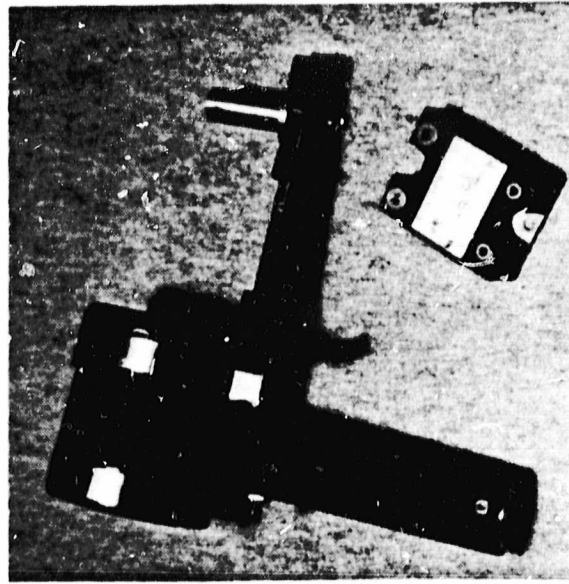
toughness and abrasion resistance of the composite fibers protects against punctures and insures leak-free operation.

The tank is now commercially available from D&H Composites, Inc., New Berlin, Wisconsin.



Low Intensity X-Ray Imaging Scope

The concept of the Lixiscope evolved from a project at the Goddard Space Flight Center for imaging x-ray and gamma ray emitting sources in our solar system. As no suitable high resolution imaging device existed, Dr. Lo I Yin and colleagues developed a modular image intensifier device described as a Low Intensity X-Ray Imaging Scope. By incorporation of a shielded radioactive source into the design, the Lixiscope became a portable fluoroscopic device for real-time imaging with many potential medical and dental applications.



After initial presentation of the Lixiscope to the scientific community at the American Nuclear Society Meeting in San Francisco, November 1977, an overwhelming number of inquiries were received by NASA.

In an attempt to satisfy some of the public's demand for additional information, a symposium was planned for presentation of preliminary evaluations of non-aerospace applications.

The BAteam was able to respond to the request by Goddard for assistance in coordinating the symposium. It was held at the Center on July 27 and 28, 1978. Representatives of several clinical research groups reported their initial impressions of the potential usefulness of the Lixiscope in medicine and dentistry. This conference provided a forum for discussion not only of potential applications but also of contemplated improvements for the Lixiscope prototype. BAteam activities included acting as liaison between prospective manufacturers and Goddard technical personnel.

As a result of the conference at Goddard and subsequent negotiations, NASA issued non-exclusive licenses under the patent on the Lixiscope to

several U.S. companies who wished to continue the development of the prototype to a commercially available device.

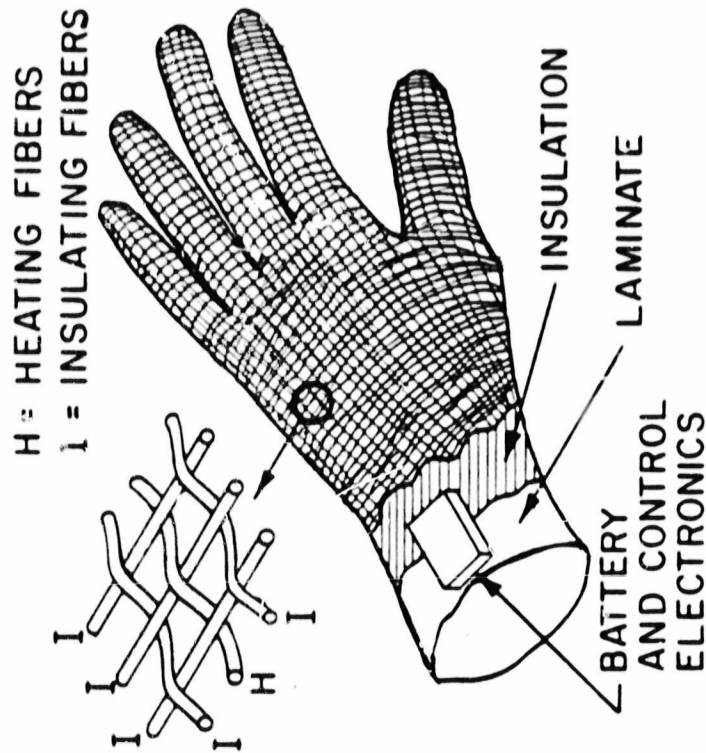
Two concerns raised at the conference were that the radioactive source used in the prototype model could not be shipped without licensing and special precautions, and that its size limited image resolution. To overcome these objections, an alternative design was suggested by a medical physicist working with the BAteam. Instead of using a radioactive isotope, the x-ray source would be a battery powered x-ray generator incorporating a microfocus rod-anode x-ray tube. The Team successfully initiated a feasibility study of the new design that has involved Goddard, researchers at the University of Wisconsin, and x-ray tube manufacturers.

Hand and Foot Warmers for Patients with Raynaud's Syndrome

When patients with Raynaud's Syndrome are exposed to cold, the peripheral blood vessels go into a reflex contraction completely cutting off the blood supply to the hands and feet. Unless protected from cold, excess tissue damage can occur. Passive insulation does not help due to the impaired circulation which, unlike in normal persons, transfers very little heat from the body's core. A practical solution is to heat the hands and feet externally to prevent any further reduction in blood flow.

A BATeam initiated search of the NASA data base revealed technical information on thermal laminates developed for defrosting space shuttle fuel cells and space suit fabrication. These were found to be applicable to the design and development of electrically heated hand and foot warmers.

The BATeam assisted Clinical Convenience Products, Inc., Madison, Wisconsin, and NASA Johnson Space Center scientists initiate a one-year jointly funded NASA-industry project for the application of NASA



technology to this problem. Upon completion of development and subsequent clinical evaluations, the hand and foot warmers will be commercially available to both Raynaud's patients and enthusiasts of winter sports.

Prevention of Flu and Common Cold Epidemics

Days of restricted activity, illness and disability due to common colds and influenza all add up to over a billion days lost from work in any given year in the United States. Prevention of these epidemics can mean a better quality of life for all of the population and a significant boost to the nation's economy.

NASA research into the preflight detection of disease and the inflight prevention of epidemics and containment of disease is being applied to solve this problem. A NASA funded project at the University of Wisconsin has provided information on the mode of respiratory virus transmission. One immediately useful outcome of this research is the

development of an environmental tool that can destroy the infecting virus before it reaches the next victim. This tool makes use of the common facial tissue as the carrier of a potent virus-killing agent. Studies conducted at Scott and McMurdo USAF Bases near the Antarctic have proven the validity of this approach.

The BATeam contacted a Fortune 500 company and found that they are interested in transferring this development into the consumer health products market. The company has decided to collaborate with a second Fortune 500 company so that substantial resources can be committed to the commercialization of this product concept.

Anthropometric Source Book

Designers of consumer products are concerned with human factors that determine how well these products meet human needs and requirements and how safely they can be used. To



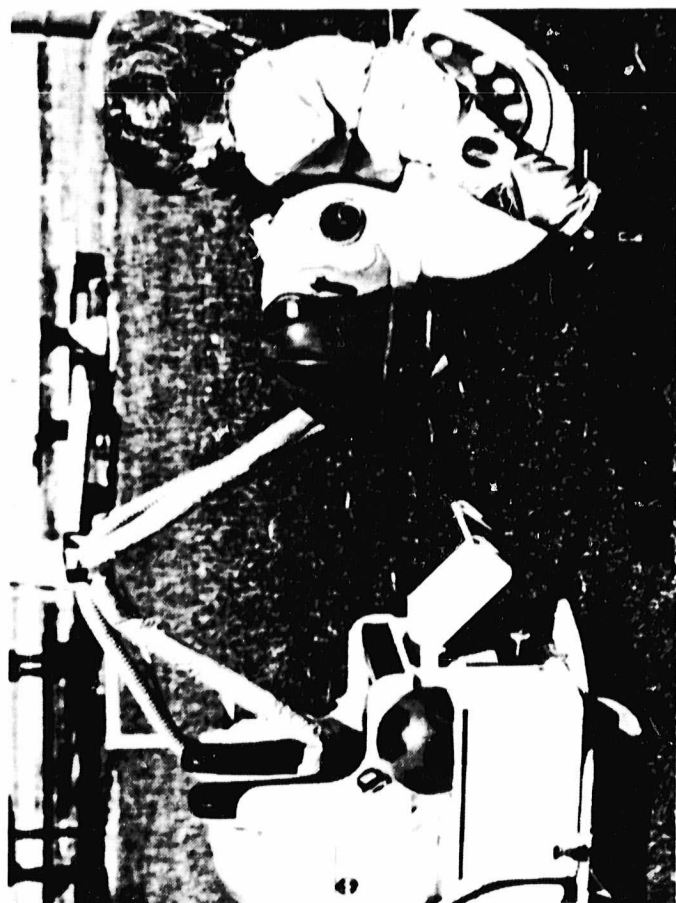
a far greater degree, NASA was obligated to consider human factors in the development of personal items used by astronauts and in the design of their temporary space homes.

As the space shuttle was being conceived, NASA realized that a broad base of anthropometric information would be needed to prepare for greater size, weight and strength diversities among space travelers than had ever been encountered before. Consequently, the agency collected information on body size, shape, mass, and on human mechanical capabilities from the world's literature and from older data bases. Then, information was added from its own studies and the entire file continually refreshed with late-breaking findings up to the time that the copy was submitted for publication. What resulted is an up-to-date, fully documented, three-volume compendium of anthropometric information covering men and women of all races and of a wide range of ages and sizes.

The BA Team, through its many medical and industrial contacts, put the NASA publication to additional uses. A garment maker in Chicago was developing a computerized system for automating the manufacture of custom clothing. He fed data on people sizes from the NASA sourcebook into his computer. The Snowmobile Safety and Certification Commission was studying man-machine interactions to develop new safety standards. It used data in the book to design test standards that accurately reflect variations in human dimensions, weight, size, and strength. A major medical supply firm was developing a new surgeon's glove and used hand sizing information contained in the book. The School for Workers at the University of Wisconsin has begun to reference the NASA document in its studies of people-related problems in industrial workplaces.

The anthropometric source book has proven to be one of the most widely useful NASA products that the BA Team has discovered to date.

DEMONSTRATIONS



Because this child lacks the normal immune response to disease, he uses a unique isolation garment originally developed for the astronauts.

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EEG Softcap Electrode System

During the Skylab missions, experiments were conducted to study characteristics of the astronauts' sleep under zero-g conditions. Sleep Monitoring Experiment M133 involved real time acquisition of the astronauts' EEG, EOG and EMG signals, as well as automated sleep staging. A special softcap electrode system was developed in order to allow the astronauts to apply the electrodes with a minimum amount of preparation in the shortest time possible. These experiments and their results were reported at the Skylab Life Sciences Symposium, August 27-29, 1974.

The BATeam recognized the potential of this work, especially the softcap electrode system, for use in a clinical environment. It is believed that the technology of sleep monitoring and automated staging can be very effectively applied in home-based monitoring of sleep for diagnosis of various sleep abnormalities such as sleep apnea, narcolepsy, etc. The usefulness of this method also is indicated for evaluation of hypnotic drugs. The softcap EEG electrode system itself has much broader applications in remote EEG acquisition, pediatric EEG and, because of the simplicity of application, even in routine EEG.

To promote and disseminate this technology, the BATeam contacted companies such as Hoffman La Roche, Beckman Instruments, and Biomedical Systems, Inc. all of which have expressed interest in further development for clinical applications.

A Sleep Monitoring Workshop was held by the BATeam at the University of Wisconsin, July 24, 1980, in cooperation with physicians of the EEG Laboratories of the UW Hospital and Clinics. Interested physicians, manufacturers' representatives and BATeam personnel discussed future directions in sleep research and applicability of NASA technology to this new field.

Subsequent encouragement received by the BATeam from leading sleep researchers across the country has been unanimous. Federal agencies such as "Project Sleep" at HEW and companies are eager to work with NASA closely to develop innovative hardware and software.

It is hoped that the effort initiated by the BATeam will continue uninterrupted so as to assure maximum utilization of NASA sleep research technology.



Multispectral Image Analysis of the Skin

Damage to the skin is quickly repaired in the normal body by a natural healing and regenerative process. But if the injury is deep, such as a third degree burn, or if the blood supply to the skin is deficient, as sometimes occurs in advanced forms of diabetes mellitus, normal repair processes may not take place. When the disease requires a limb amputation, inadequate skin perfusion may complicate treatment by preventing the healing of the skin flap over the stump. The only recourse may be to perform another amputation at a higher level.

At the Jet Propulsion Laboratory, NASA scientists and engineers have spent years analyzing images transmitted from space. Much of this image analysis capability is applicable to problems on earth. One particularly successful technique--multispectral image analysis--has been used to provide diagnostically useful information about the human skin.

In the NASA multispectral system, an artificially colored image is produced by making unusual use of a wider range of spectral energy reflected from the object of interest. Unlike a normal photograph which is a registration of visible

light only, the NASA system processes non-visible infrared spectral energy and includes it in the finished picture. The colors in the reconstructed image are dictated by measuring the intensities of spectral components of the reflected energy at each image point, calculating ratios of these components, and then assigning specific colors to locations in the image based upon the results of these calculations.

Researchers have demonstrated that by a judicious selection of the number, sharpness and wavelength of the bandpass filters, diagnostically significant features in the object can be enhanced. Colors and patterns in the false color image reveal whether some of the skin is burned through to the dermis. This skin will not grow back, and prompt grafting to the area is recommended. Studies are now underway to determine if the multispectral imaging technique also can indicate by color coding, the lowest point at which a successful amputation can be made.

The BA Team made three noteworthy contributions for the transfer of this new imaging technology into medical science. When clinical feasibility studies of the burn

system were nearly complete, the Team convened a meeting of businessmen from ten manufacturing companies to inspect the device. The Team also helped elucidate the limb amputation problem and assisted with the initiation of a project designed to study this particular application.

The third service occurred as a consequence of working towards the development of new applications for the NASA technology. Team members discovered that an entrepreneur had independently learned about the JPL accomplishment and had modified the concept to develop a non-imaging multispectral burn analyzer. Collaboration was established by the Team between the entrepreneur and a physician known to be investigating new ways to analyze limb viability, thereby increasing the chances of a successful implementation of the basic concept.

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